Using Meteorological Radar in Communication System Design

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The 25 m fully steerable Chilbolton Advanced Meteorological Radar (CAMRa) based at Chilbolton, Hampshire

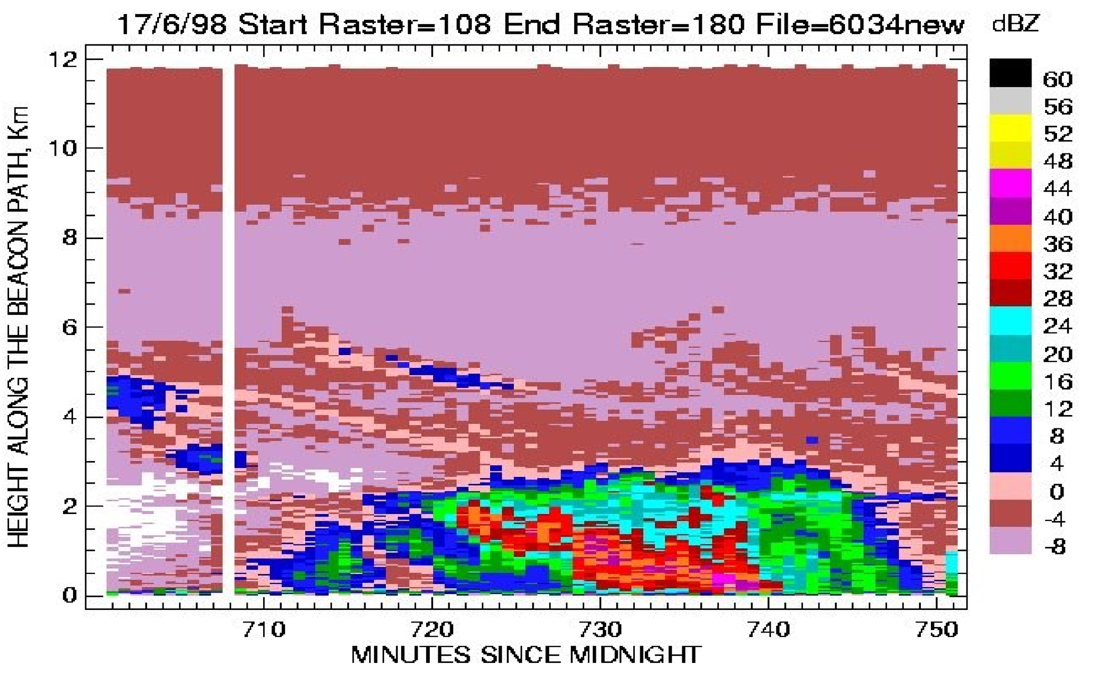
Due to the recent expansion in mobile communications there has been an increased demand for more bandwidth to be made available to provide for new applications such as mobile Internet and video-on-demand. However, at lower frequencies the electromagnetic spectrum is very congested. This means that to provide the required bandwidth for these new services it is necessary to move to higher frequencies.

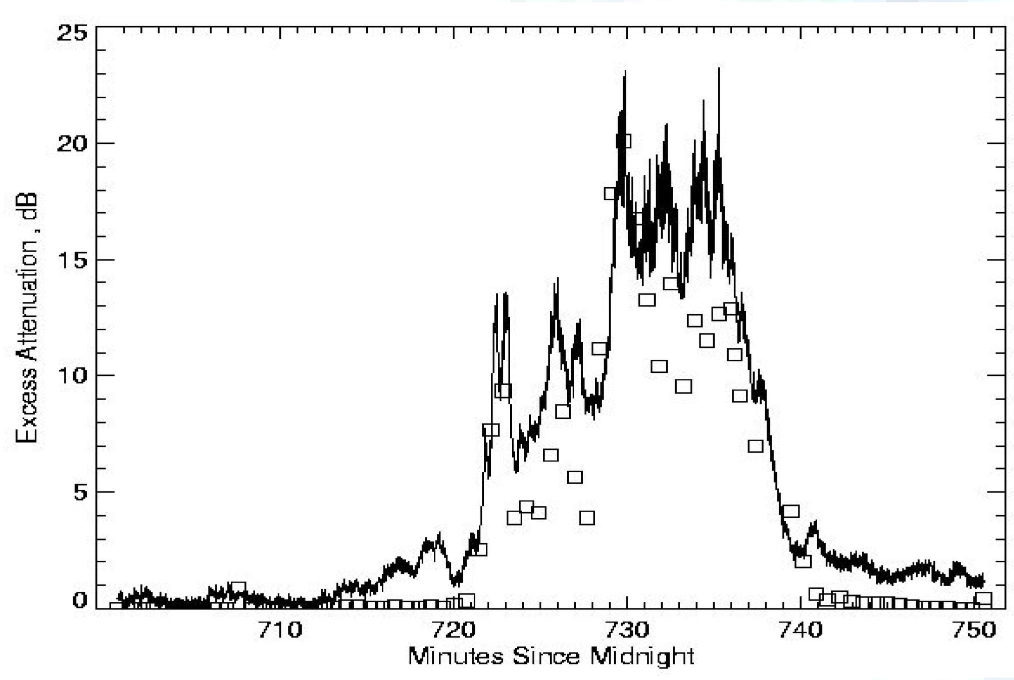
The Radio Communications Research Unit studies the effects of the atmosphere on radio links in order to produce the long term statistics required to properly design and efficiently run the next generation of radio communications systems. To produce these statistics we monitor a number of radio links, including satellite and terrestrial links. We also study in detail the different atmospheric events such as rain clouds that cause disruption of the signal, using the Chilbolton Advanced Meteorological Radar (CAMRa).

Both earth-space and terrestrial communications systems operating at extra high frequencies (EHF) experience severe signal degradation or attenuation due to the effects of rain and atmospheric gases along the radio path. For satellite paths the effect of clouds must also be taken into account. The characteristics, eg, length, fade depth etc. of the attenuation varies according to the meteorological events that cause them. For this reason, it is necessary to study meteorological events in detail in order to be able to understand the underlying mechanisms involved, and to work on ways to compensate for the fades and provide a better service.

CAMRa is the world's largest fully steerable meteorological radar. It is a 3 GHz multi-parameter radar, based at Chilbolton, in Hampshire, where it provides valuable information on the spatial and temporal characteristics of rain and clouds. The 25m antenna is capable of producing a wide range of scans, enabling us to see in detail weather features such as rain and clouds and giving us information about their internal structure.

RCRU satellite receiving station at Sparsholt in Hampshire (top).





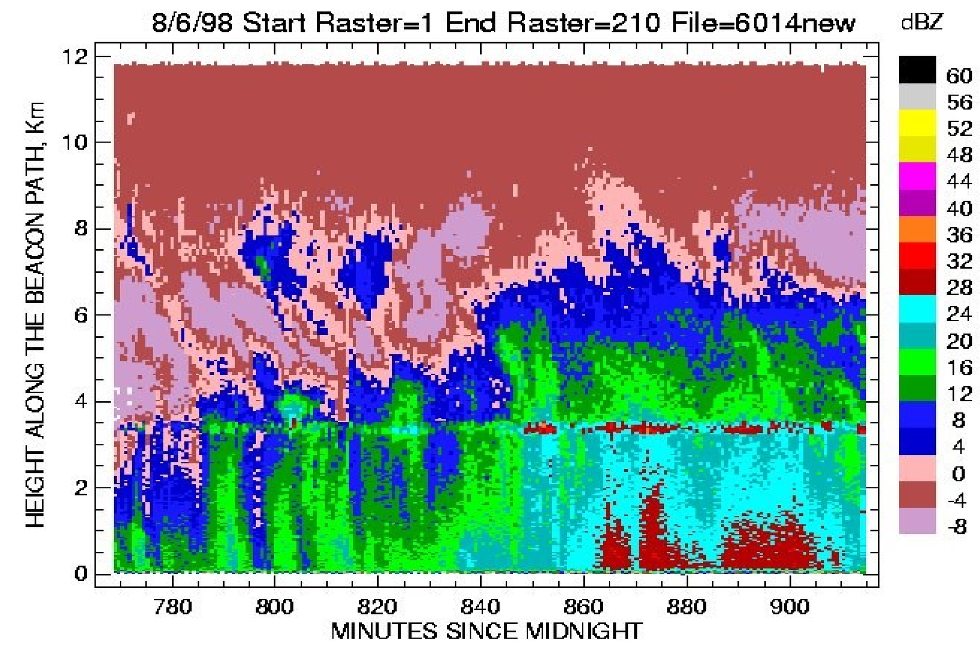
Radar scan along the path from the ground station to the ITALSAT satellite of a convective rain event (top) with the corresponding attenuation as experienced by the 50 GHz beacon carried on board ITALSAT (bottom). As can be seen the beacon experiences considerable attenuation due to the rain. The black boxes show the radar predictions of the attenuation.

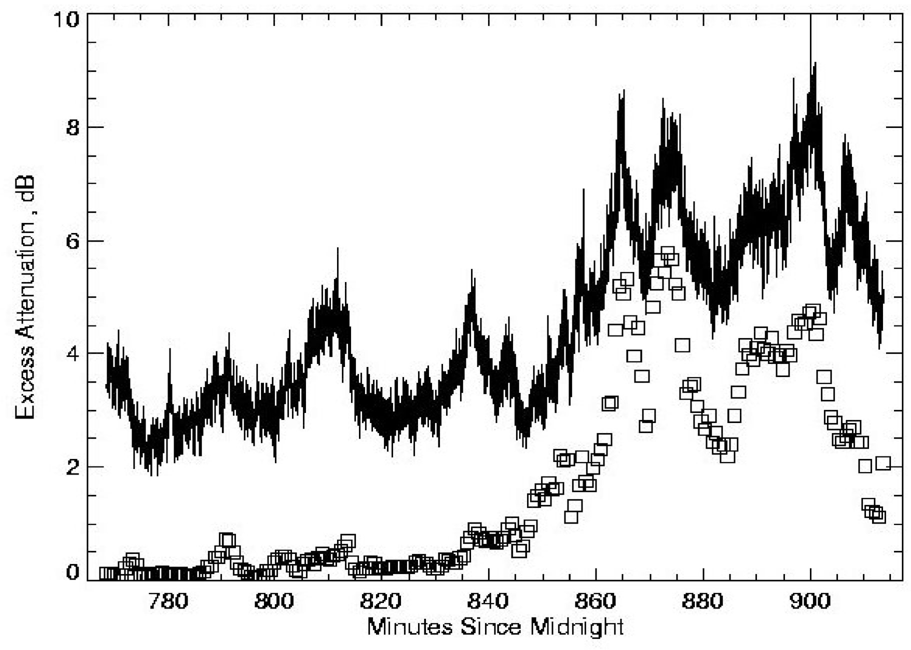
Rain events are generally divided up into two main categories as follows:

<u>Convective rain</u> events (left) generally last only a short time but have heavy rainfall and high radar reflectivity. Scans of the rain show that the interior of the rain cloud is very turbulent. Convective events generally occur during the summer and autumn months.

<u>Stratiform rain</u> (right) lasts longer than convective rain and is generally lighter. It is less turbulent, and is characterised by a bright band in the radar echoes which occurs at the altitude where the ice crystals in the atmosphere are melting to form rain. Stratiform rain generally occurs in the winter and spring months.

The radar can also be used to predict the attenuation experienced by the beacon signal (as shown by the black boxes on the lower plots). This prediction works well, though in the case of the stratiform rain (right) the prediction underestimates the measurements. This is due to the large numbers of very small raindrops that cause very high attenuation at 50 GHz, but do not cause as much radar reflectivity.

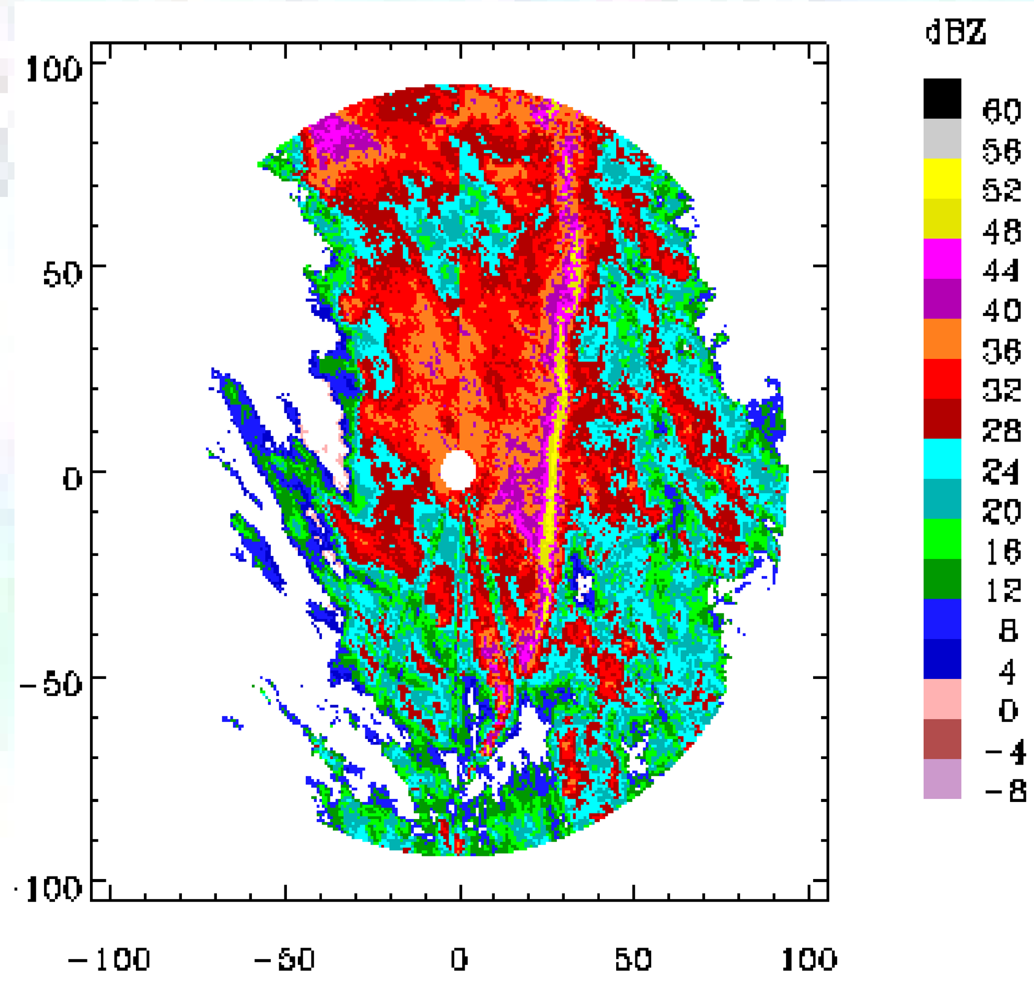




Radar scan along the path from the ground station to the ITALSAT satellite of a stratiform rain event (top) with the corresponding attenuation as experienced by the 50 GHz beacon carried on board ITALSAT (bottom). The beacon experiences less attenuation than during the convective event, because the stratiform rain was not as heavy, even though it lasted a lot longer than the convective event. The black boxes show the radar predictions of the attenuation.

Horizontal scans of the radar (right) show how the rain is distributed in space. Knowing the underlying statistics of this spatial variation is very important when it comes to choosing the best location for a satellite receive station, or the two ends of a terrestrial path.

It is possible to take advantage of the spatial variation of rain by having more than one terrestrial path or satellite receive site connected to the same network. When the rain occurs over one site, if the other is sufficiently far away then it will not be affected by the rain. Switching to the station that is least affected by the rain provides dramatic improvement in system availability.



A 360° horizontal radar scan (left) showing a squall line that moved over the area on the 24th October 1995. The radar is located at the centre of the white circle in the middle. The high values of reflectivity in the squall line (to the right of the central circle) show that rainfall rates were in excess of 80 mm/hr.